Sustainable Water Management Initiative
Technical Subcommittee

Presentation Title: Safe Yield Components

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Safe Yield Components

Basin yield

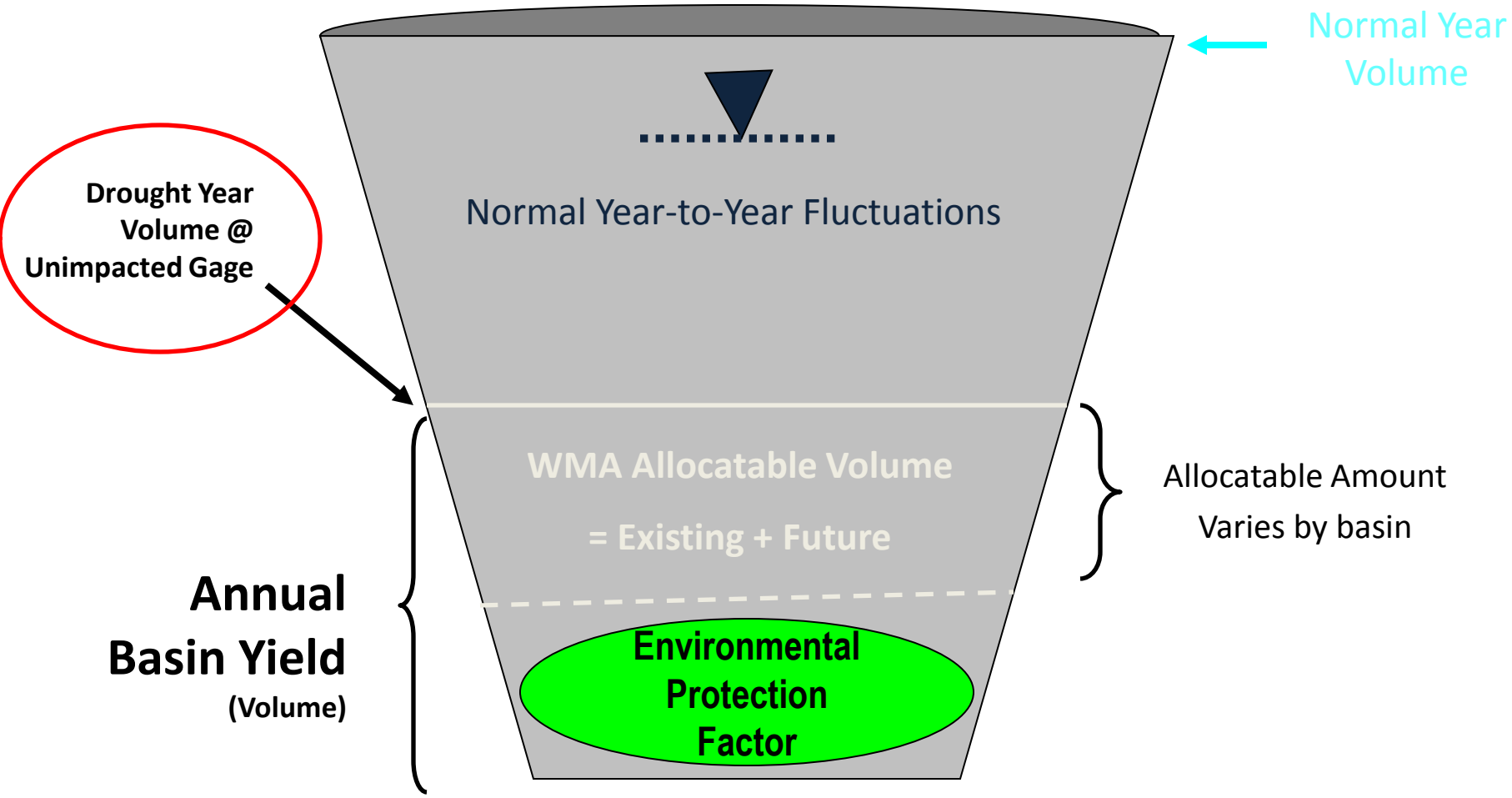
Storage Credits

Linda Hutchins, DCR

SWMI Technical Committee

September 14, 2010

Safe Yield Approach
with an Environmental Protection Factor



Major Basin Safe Yield=

Basin Yield

+

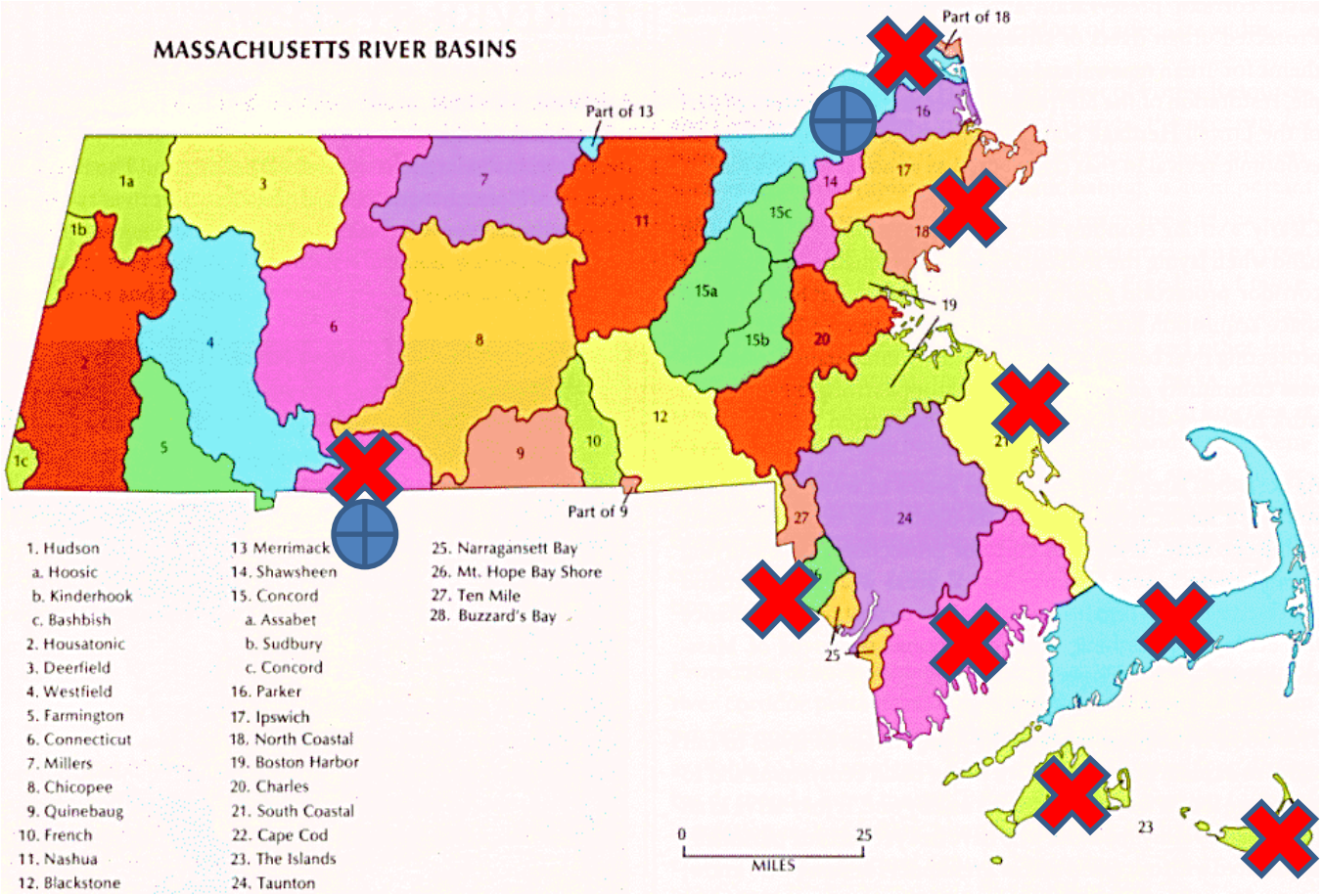
Reservoir Storage Credit

-

Environmental Protection Factor

USGS Sustainable Yield Estimator

- Calculates Daily Estimated Unimpacted Flows
- Calculates Daily Estimated Impacted Flows
- Generates Period of Record 1960-2004



Basin Yield

Annual Drought Volume
Calculated from SYE Statistics
using Monthly 90th percentile low flows

Millers													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Q98	0.24	0.34	0.56	0.92	0.44	0.21	0.14	0.09	0.08	0.16	0.22	0.27	0.31
Q95	0.34	0.43	0.74	1.05	0.54	0.25	0.16	0.14	0.12	0.20	0.26	0.40	0.38
Q90	0.44	0.57	0.91	1.28	0.70	0.30	0.20	0.15	0.15	0.23	0.34	0.48	0.48
Q80	0.62	0.72	1.16	1.72	0.98	0.40	0.25	0.20	0.21	0.31	0.51	0.63	0.64
Q75	0.70	0.80	1.32	1.93	1.11	0.46	0.26	0.22	0.22	0.34	0.58	0.73	0.72
Q50 (Medians of Daily Means)	1.11	1.23	2.24	2.95	1.63	0.84	0.39	0.33	0.33	0.53	1.11	1.29	1.16
Median of Monthly Means, cfsm	1.54	1.49	2.94	4.11	2.06	1.02	0.56	0.40	0.46	0.66	1.31	1.54	1.50

Monthly values are time-weighted and “rolled up” into an average annual value *

* =((Jan x 31 days) + (Feb x 28 days) + (Mar x 31 days) + (Apr x 30 days) + (May x 31 days) + (Jun x 30 days) + (Jul x 31 days) + (Aug x 31 days) + (Sep x 30 days) + (Oct x 31 days) + (Nov x 30 days) + (Dec x 31 days))/365 days

Monthly Q90 Rollup:

A synthesized low-flow year.

How does it compare to real years?

What is the recurrence interval?

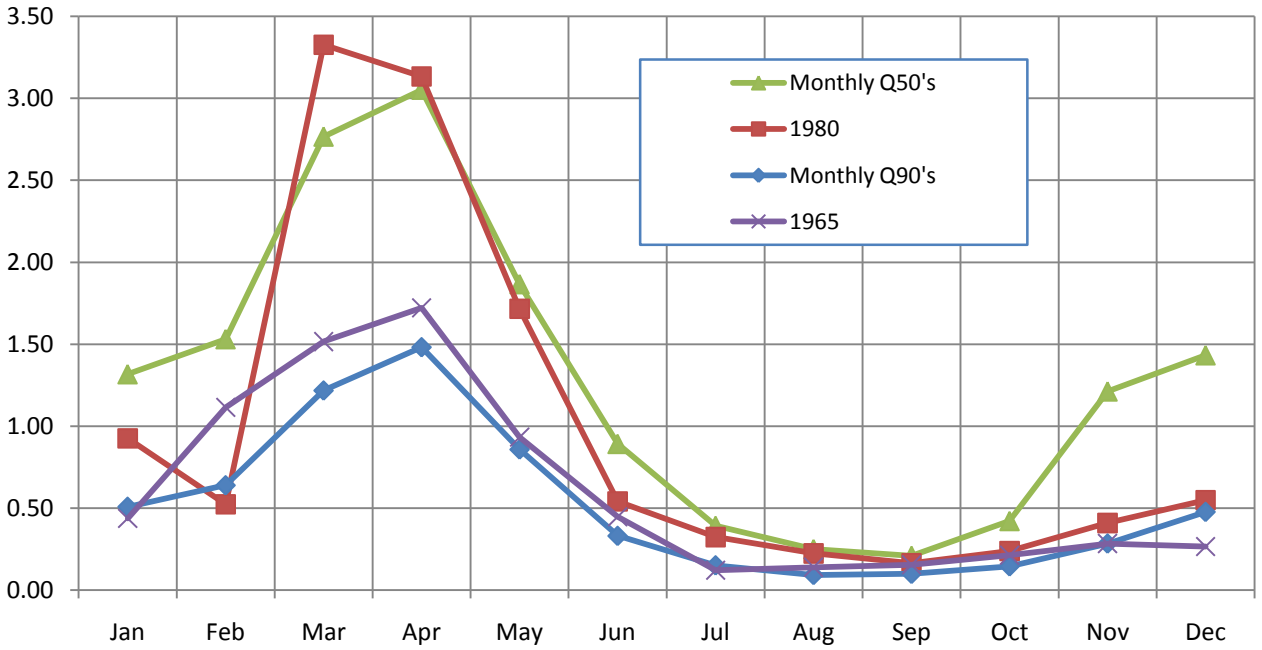
We compared all the SYE Simulated Years

	Monthly Median of Daily Mean Flows, cfsm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1961	0.88	0.88	3.52	6.13	2.52	1.04	0.53	0.31	0.41	0.45	0.89	0.95	1.54
1962	1.76	0.95	2.02	4.58	1.88	0.65	0.24	0.28	0.17	0.99	2.73	2.11	1.53
1963	1.70	1.16	2.59	2.24	1.60	0.79	0.20	0.10	0.06	0.06	1.33	1.52	1.11
1964	1.29	1.72	2.98	2.66	1.60	0.52	0.46	0.06	0.04	0.12	0.15	0.39	1.00
1965	0.44	1.12	1.52	1.72	0.93	0.45	0.12	0.14	0.15	0.21	0.28	0.27	0.61
1966	0.33	1.17	2.72	1.23	1.00	0.46	0.12	0.10	0.17	0.26	0.73	0.61	0.74
1967	0.81	0.68	1.83	3.90	2.97	1.38	0.61	0.30	0.21	0.25	0.66	1.15	1.23
1968	1.34	1.25	2.97	1.66	1.07	1.80	0.67	0.20	0.12	0.35	1.44	1.63	1.21
1969	1.31	1.56	2.22	3.89	1.52	0.57	0.22	0.24	0.21	0.28	2.33	2.71	1.42
1970	1.58	2.39	1.60	2.70	1.70	0.93	0.57	0.14	0.15	0.30	1.29	1.02	1.19
1971	0.78	1.82	3.54	3.29	2.57	0.99	0.33	0.10	0.14	0.24	0.41	1.66	1.32
1972	1.25	1.53	4.20	3.70	2.57	3.31	1.96	0.33	0.55	0.62	2.38	2.56	2.08
1973	2.44	2.15	3.26	4.78	3.17	1.09	0.84	0.26	0.13	0.14	0.65	1.96	1.74

Monthly Q90 Rollup:

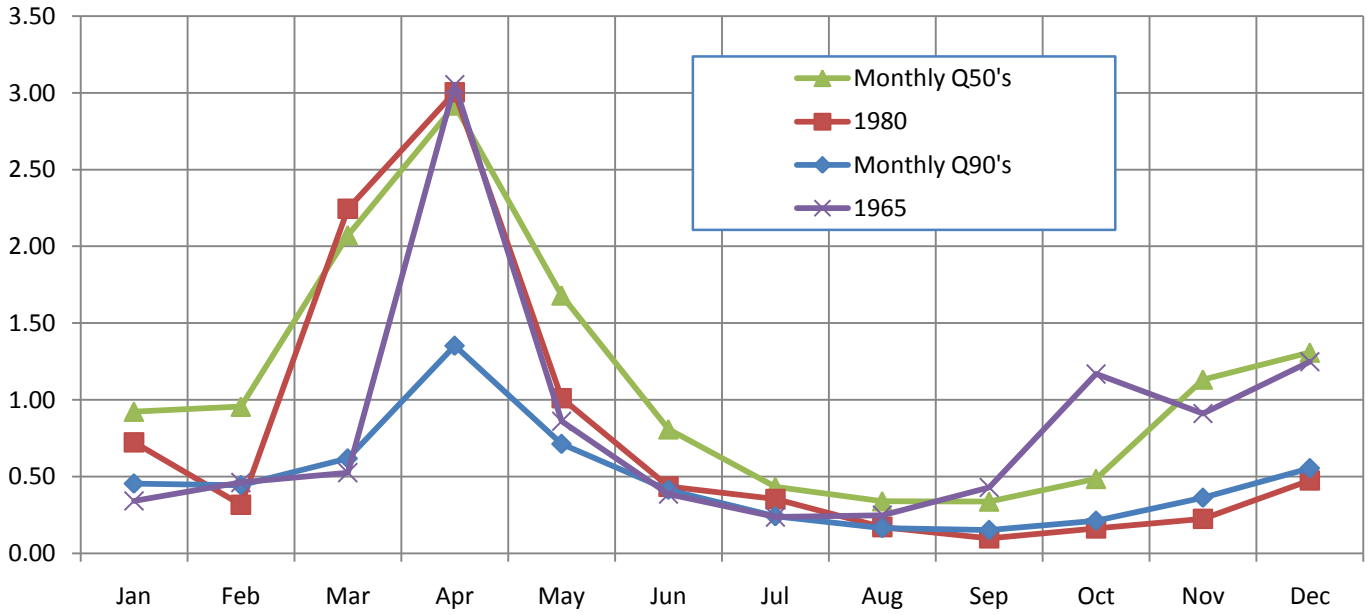
A synthesized low-flow year.
How does it compare to real years?

Shawsheen River Basin
Monthly Q50's (medians of daily flows)
Monthly Q90's (90th percentile of daily flows) = 0.52
1980, 1965=0.61 (Monthly medians of daily flows)

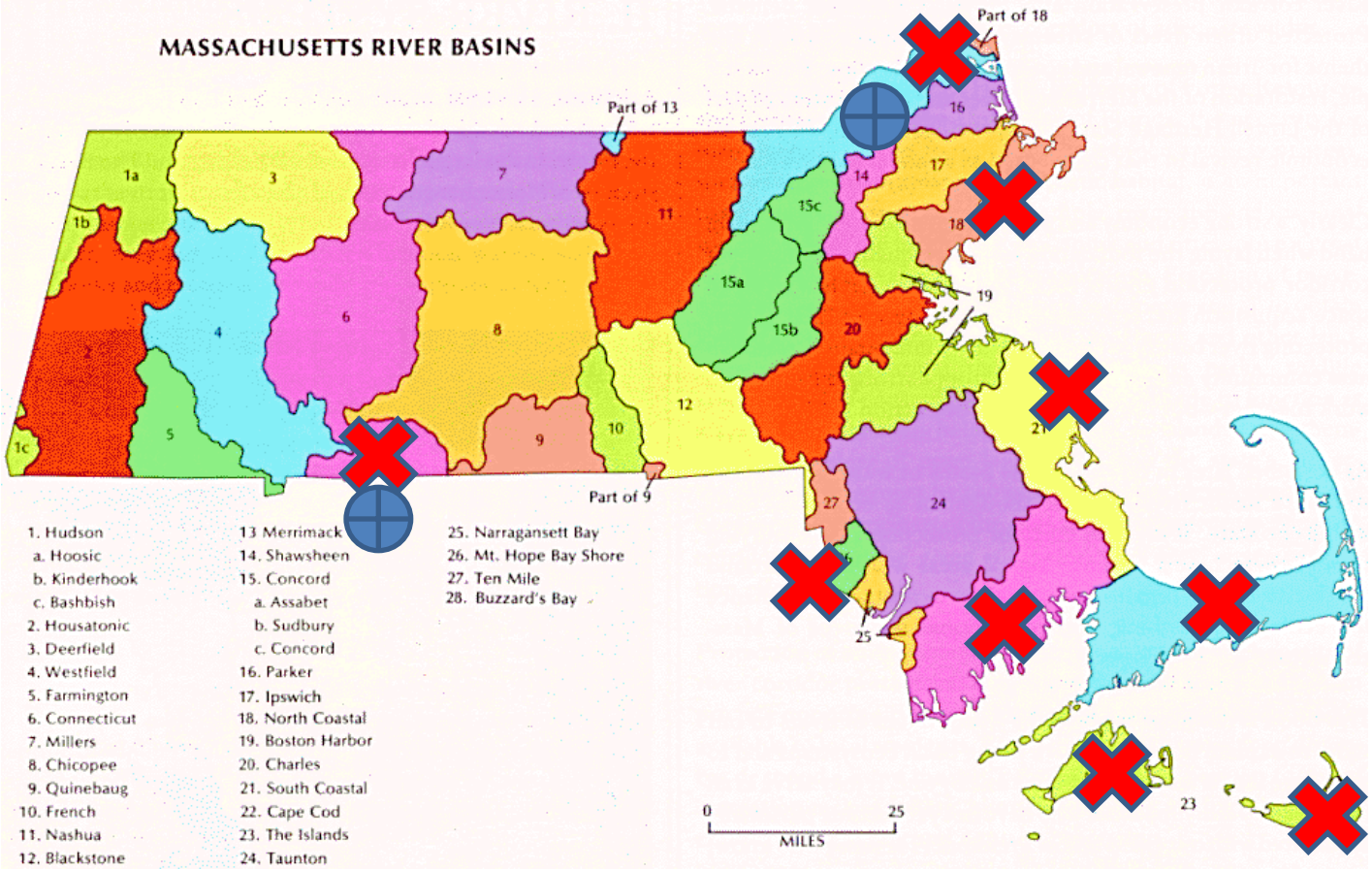


In some basins Monthly Q90 rollup is much below minimum actual year

Hudson River Basin
Monthly Q50's (medians of daily flows)
Monthly Q90's (90th percentile of daily flows) = 0.47
1980=0.77, 1965 (Monthly medians of daily flows)



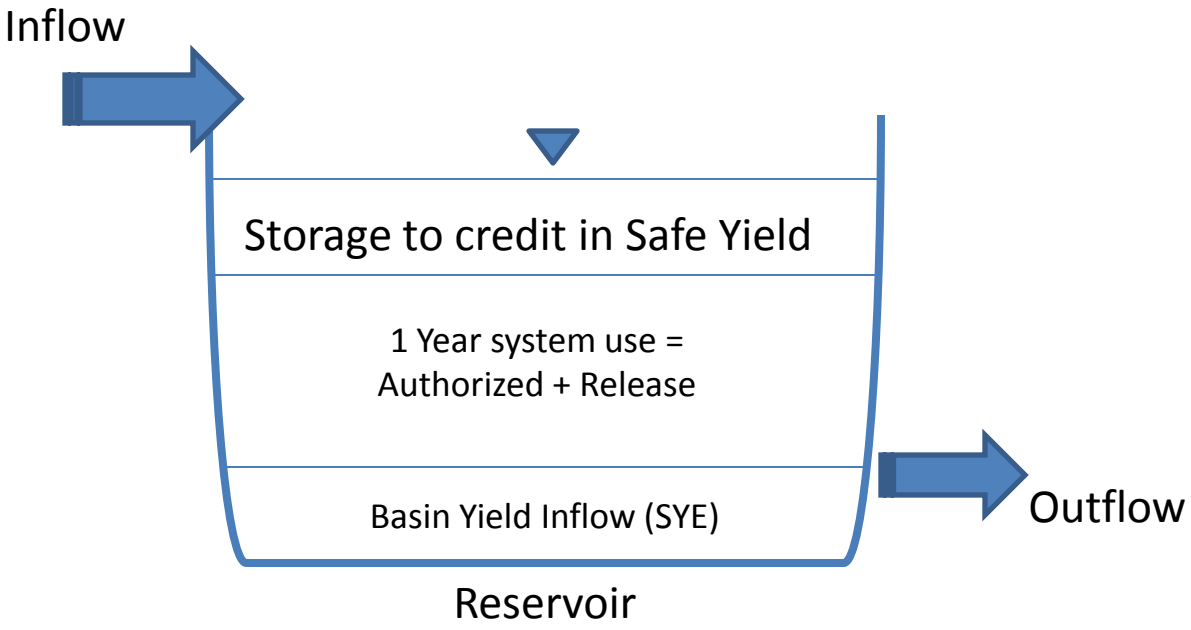
SYE can't be used for all major basins



Apply a MGD/square mile value to coastal basins for safe yield?
Use actual gage data for major regional rivers (net values)
Use some version of 2009 recharge calculations for safe yield?

Safe Yield
Reservoir Storage Credits

Safe Yield Reservoir Storage Credits



- credit basins with large amounts of storage:
  - Storage exceeds one year of drought year inflow
  - storage also exceeds one year of authorized water use.

- The first year of inflow cannot be added to the Safe Yield, since it is already included in the SYE flow estimate for the basins.

Safe Yield Storage Credit

- When storage is greater than both Basin Yield flow and Maximum Annual Use, maximum "credit" to basin safe yield = average annual inflow rate to the reservoir

- A lesser amount of "excess storage" could be credited for amounts of storage above one year of water use but less than the average annual inflow volume

- For multiple reservoir systems within a single major basin that pump between reservoirs, the total volumes, inflows, and withdrawals can be analyzed together

Proposed Reservoir Storage Credits

- Quinebaug (Southbridge) = 0.07 MGD
- Housatonic (Lee) = 0.12 MGD
- Boston Harbor (Mystic Lakes) = 1.62 MGD

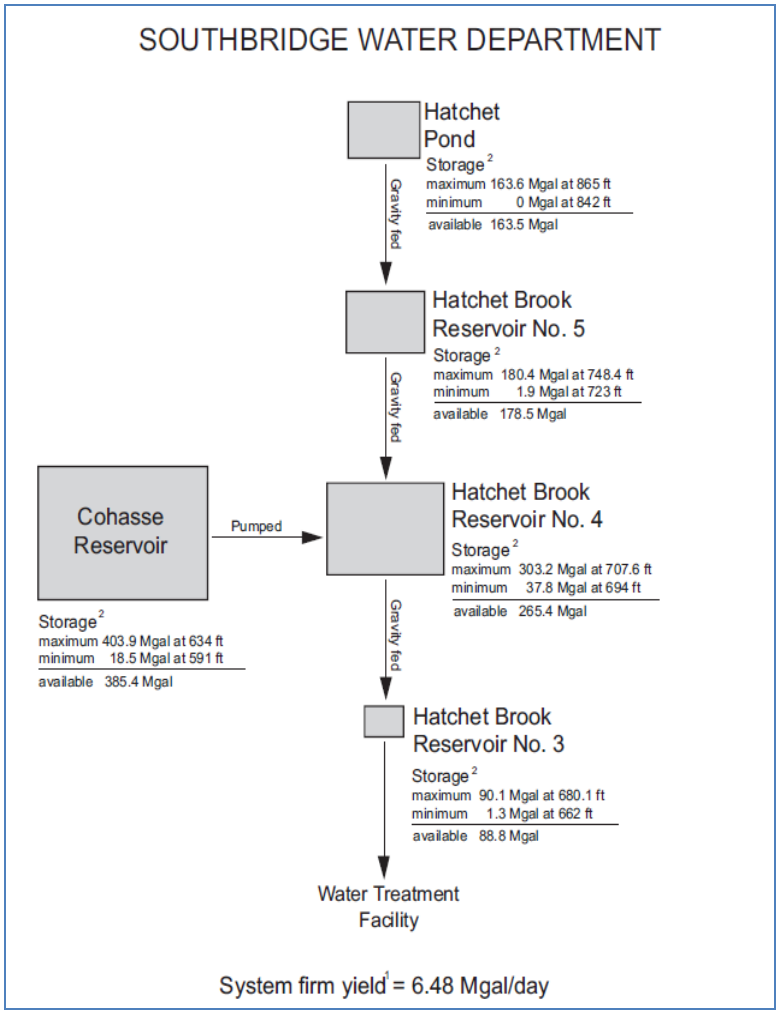
- Westfield (Springfield) = 62.6 MGD

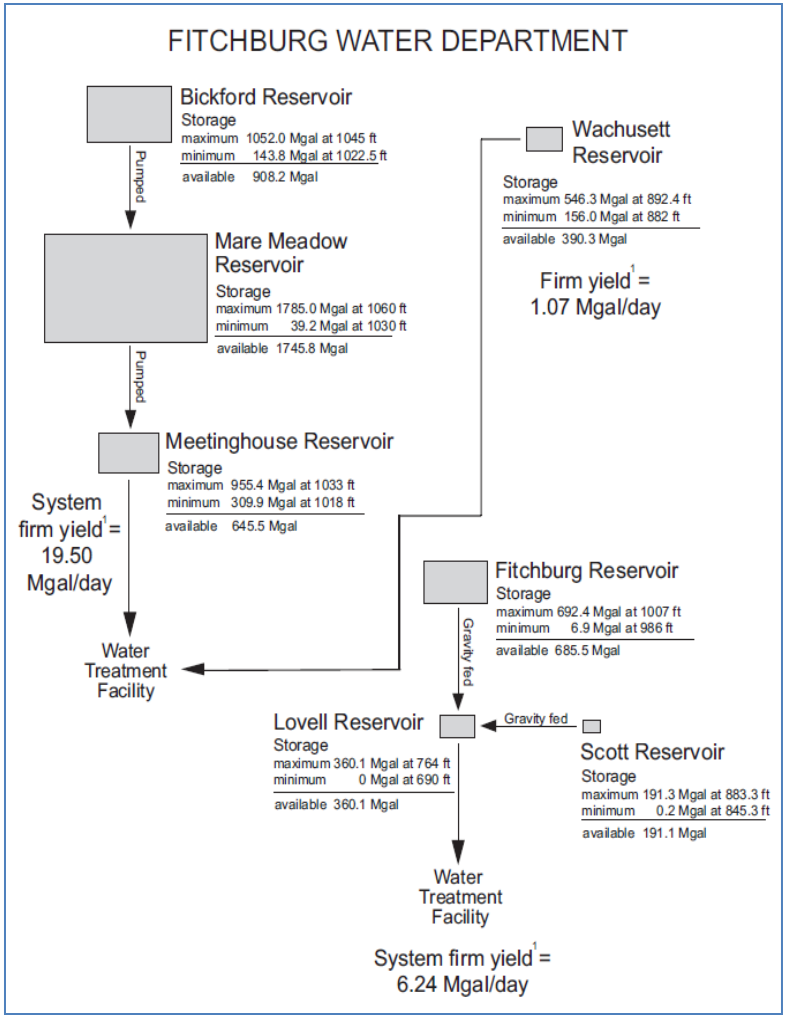
- Nashua (MWRA, Fitchburg) = 141.6 MGD
- Chicopee (MWRA, Fitchburg) = 250.1 MGD

Step 1: Determine Reservoir Storage

Volume in millions of gallons

USGS SIR 2006-5044 (Firm Yield)





Example– MWRA Quabbin (Largest proposed Storage Credits)

Step 1: Quabbin Reservoir Storage Volume = 333,720 Million Gallons

Step 2: **Determine Basin Yield Reservoir Inflow**

Use Basin Yield for Major Basin to scale reservoir inflow to reservoir drainage area

Major Basin Yield (MGD)/Basin Area (Sq Mi) X Drainage Area to Reservoir = Basin Yield Reservoir Inflow, MGD

Multiply Reservoir Inflow X 365 days/year = Reservoir Inflow in Millions of Gallons (MG)

Quabbin BYRI = 0.54 cfsm x 186 sq mi x 365 days/yr = 23,652 MG

Step 3: Compare Reservoir Storage Volume to Basin Yield Reservoir Inflow

If Reservoir Storage < Basin Yield Reservoir Inflow	Then no credit to safe yield amount
If Reservoir Storage > Basin Yield Reservoir Inflow	Then continue to Step 4

Reservoir Storage 333,720 >> Basin Yield Reservoir Inflow 23,652 MG

Quabbin Example Continued

Step 4: Determine reservoir system authorized withdrawal in MGD

Add WMA registered and permitted withdrawals

Quabbin Authorized withdrawal = 186.7 MGD (WMA Registered)
= 68,146 MGY

Step 5: Determine Release Requirement, if any in MGD

Quabbin release requirement = 14,386 MGY

Step 6: Calculate Maximum Annual System Use

= Authorized Withdrawals + Release Requirement (MGD)

Multiply Maximum Annual System Use (MGD) X 365 days = MG

Quabbin Max Ann Use = 82,532 MGY + 14,386 MGY = 106,184 MGY

Quabbin Example Continued

Step 7: Compare Reservoir Storage to Maximum Annual System Use

If Reservoir Storage < Maximum Annual System Use — Then no credit to safe yield amount

If Reservoir Storage > Maximum Annual System Use — Then continue to Step 8

Quabbin storage = 337,720 >> Max use 106,184 MG

Step 8: Compare Reservoir Storage to Basin Yield Reservoir Inflow + Maximum Annual System Use

If Reservoir Storage < BYRI+Max Use — Then safe yield credit = (Reservoir Storage – Max Use)/365 (

If Reservoir Storage > BYRI+Max Use — Then continue to Step 9

Quabbin Storage 333,720 MG >> BYRI 23,652 MG (*with 194,102 MG to spare)*

Step 9: Safe Yield Credit = Reservoir Average Annual Inflow

Use SYE to calculate average annual inflow at a point coincident with the reservoir dam or outlet

Convert resultant flow in cfs to MGD (cfs/1.55 = MGD)

Res. Ave. Ann. inflow = Ware (47.3 MGD + Quabbin 195.2 MGD = 242.5 MGD (full credit)

MWRA Wachusett

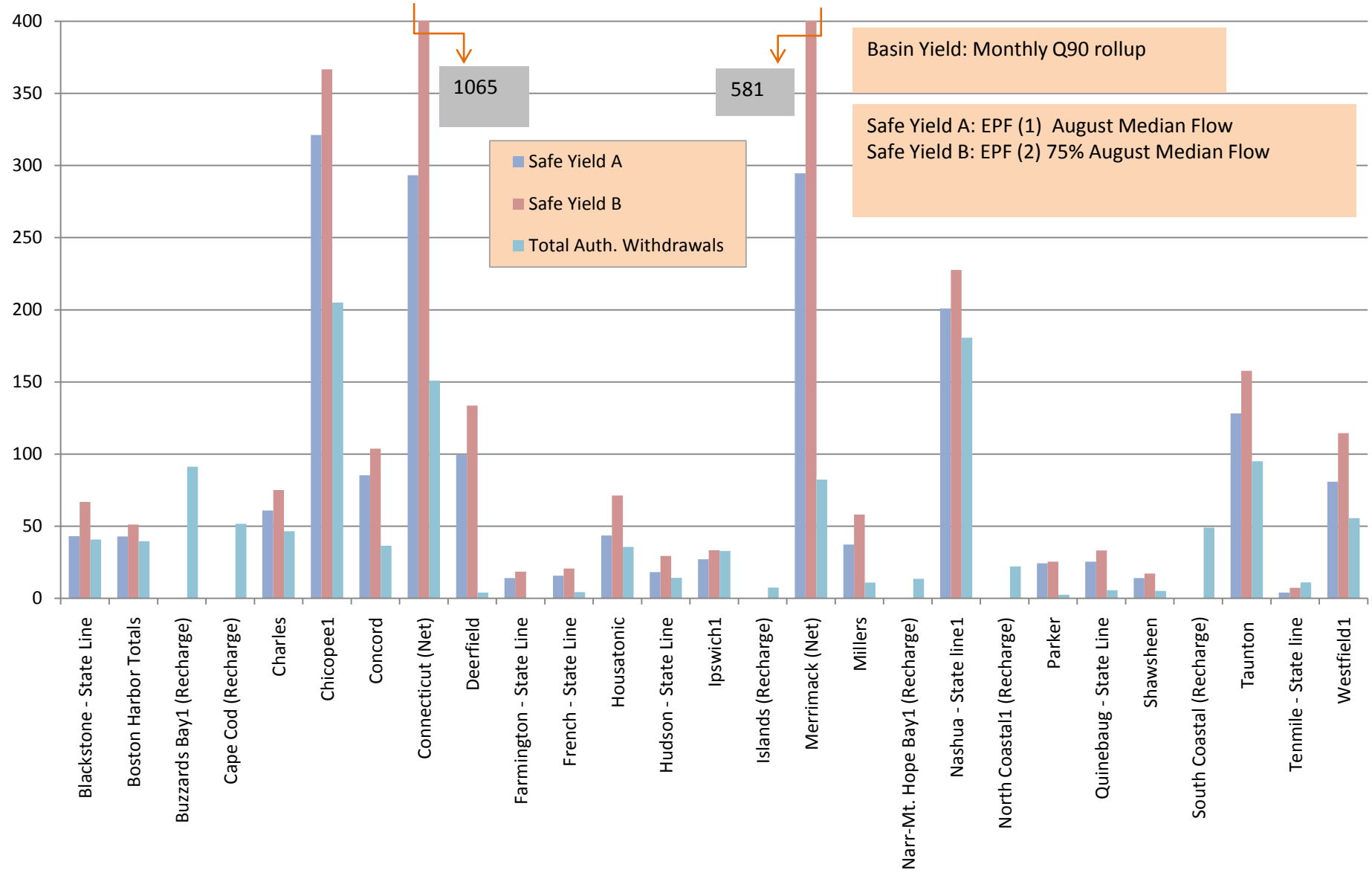
1. Reservoir storage = 65,000 MG
2. BYRI = 14,614 MG
3. Storage > BYRI (yes)
4. Authorized withdrawal = 126.12 MGD = 46,034 MGY
5. Release requirement = 624 MGY
6. Max annual use = 46,658 MGY
7. Storage > Use ? (Yes)
8. Storage > BYRI + Use? Yes
9. Safe yield credit = average annual inflow = 127.4 MGD

Safe Yield Results

SWMI Safe Yield Options

MGD

9/14/10



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SWMI Safe Yield Options (Continued)

MGD

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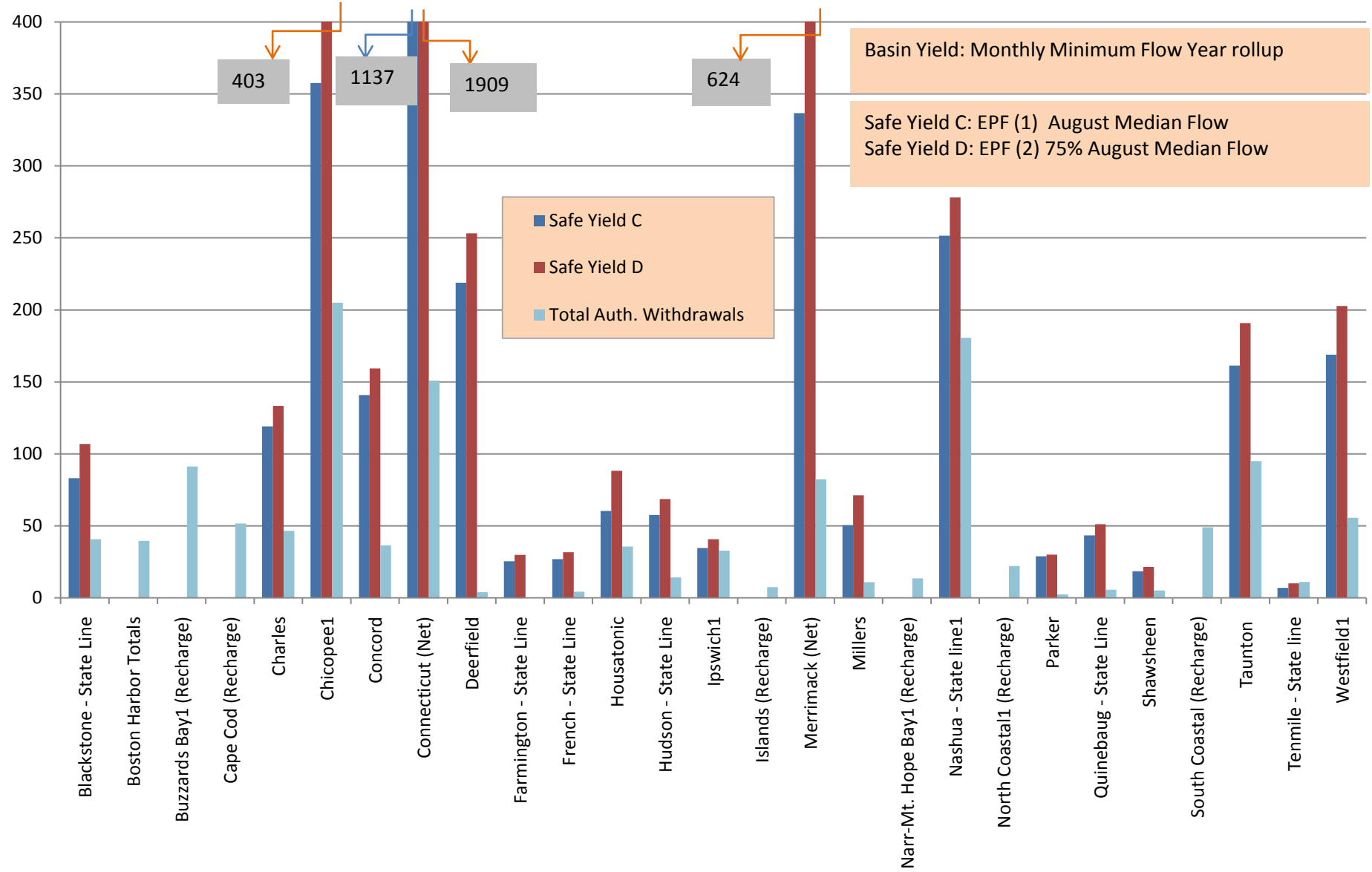

SWMI Safe Yield Options

MGD/mi2

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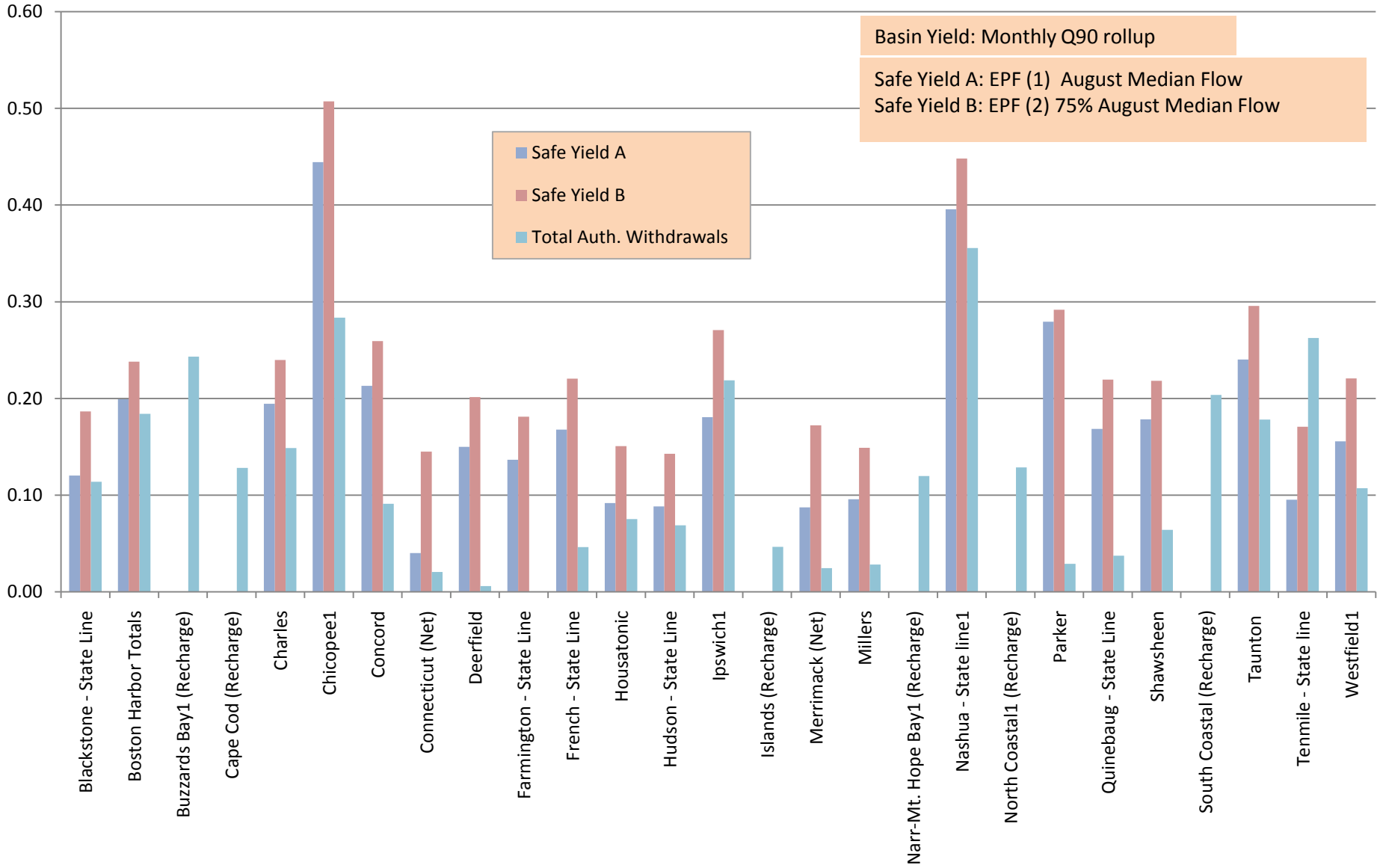

SWMI Safe Yield Options (Continued)

MGD/mi2

9/14/10